United States
Department of
Agriculture

Soil
Conservation
Service

Bismarck
North Dakota

South Heart Flood Plain Management Study Stark County, North Dakota

Prepared for the City of South Heart and the Stark County Water Resource District

In cooperation with the Western Soil Conservation District and the North Dakota State Water Commission

April 1985

FLOOD PLAIN MANAGEMENT STUDY

ON

THE HEART RIVER AND SOUTH BRANCH OF THE HEART RIVER

IN THE VICINITY OF SOUTH HEART, NORTH DAKOTA

Prepared By

United States Department of Agriculture
Soil Conservation Service
Bismarck, North Dakota

For the

CITY OF SOUTH HEART, NORTH DAKOTA

AND THE

STARK COUNTY WATER RESOURCE DISTRICT

In Cooperation with the
Western Soil Conservation District
and the
North Dakota State Water Commission

F O R E W A R D

This report defines the flood characteristics along and adjacent to the Heart River and South Branch of the Heart River in Stark County, North Dakota. Land uses along the stream are transportation, residential, commercial, industrial, agricultural, recreational and wildlife use. Despite moderate agricultural damage by floods in previous years, there is increasing pressure for development of the flood plain.

This cooperative report was prepared for the guidance of local officials in planning land use and regulating development within the flood plain. The 10-, 50-, 100- and 500-year frequency flood events were selected to represent degrees of major flooding that could occur in the future. The 100-year [1/] and the 500-year [2/] floods are frequencies considered for planning land use and development in the flood plain. Potential flooded areas are defined by flood hazard photomaps that show the approximate areas subject to inundation. Flood profiles show the water surface elevations for the selected events. Typical valley cross sections are presented to indicate ground levels across the width of the valley with the overlying flood depths. The flood profiles and flooded area photomaps are based on conditions at the time of the study.

This report does not imply any federal authority to zone or regulate use of the flood plain; authority to zone and regulate rests with state or local governments. Technical data provided are for the potential future adoption of local land use controls to regulate flood plain development. Since this report identifies flood problems, it will give guidance for the development,

1/ A flood which has a 1 percent chance of being equaled or exceeded in any year (also called "base" flood).

2/ A flood which has a 0.2 percent chance of being equaled or exceeded in any year.

with environmental considerations, of flood damage reduction techniques such as flood control structures, removal of obstructions and flood proofing for use in an overall Flood Plain Management Program.

The assistance and cooperation of the city of South Heart, Stark County Water Resource District, Western Soil Conservation District, North Dakota State Water Commission and private citizens in carrying out this study is appreciated.

SOUTH HEART FLOOD PLAIN MANAGEMENT STUDY

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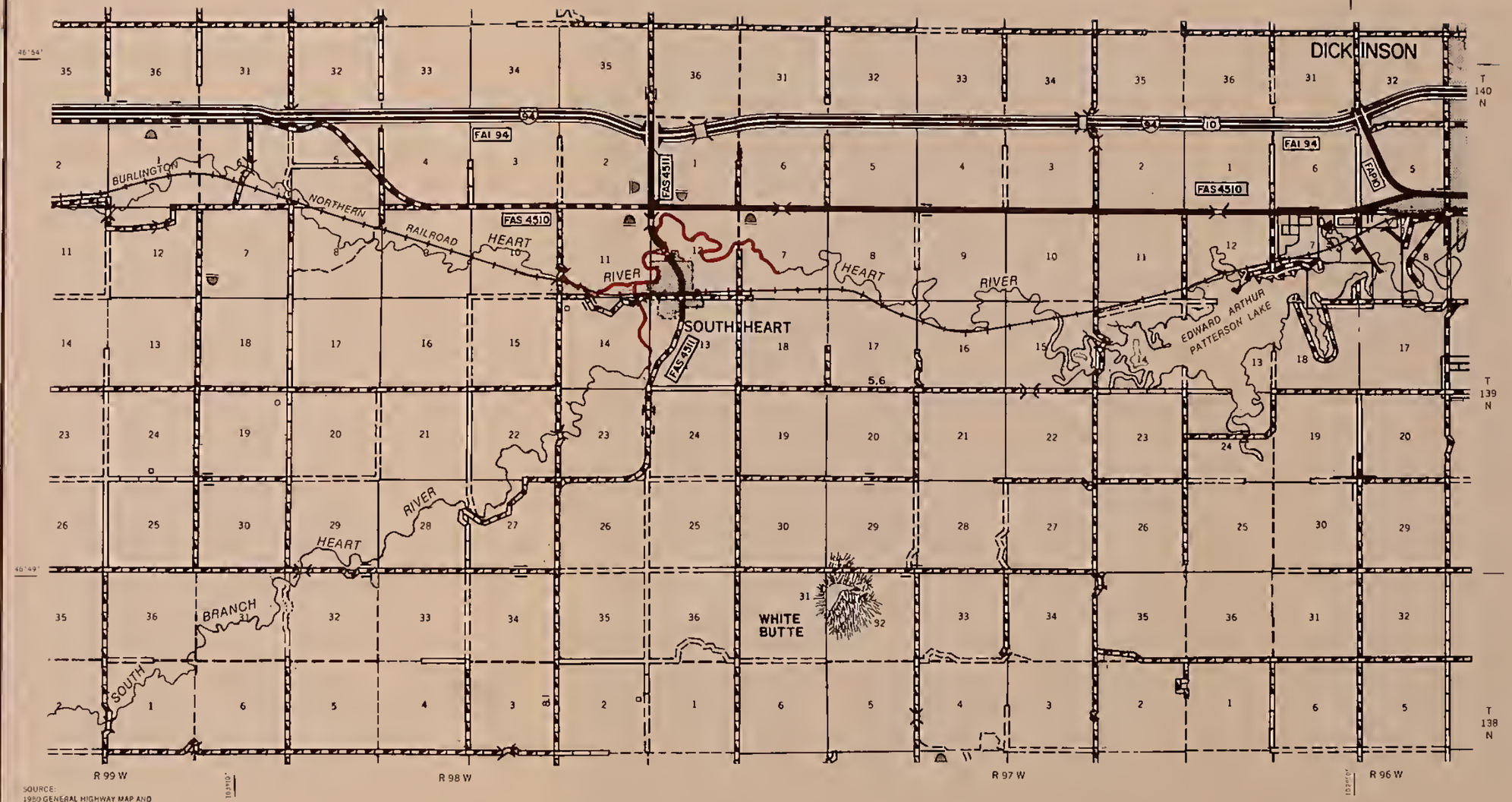

LEGEND

- TOWN
- INTERSTATE HIGHWAY
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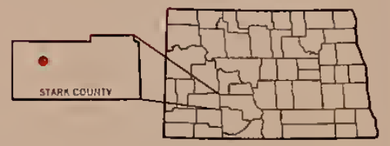


VICINITY MAP

SOUTH HEART

FLOOD PLAIN MANAGEMENT STUDY

STARK COUNTY, NORTH DAKOTA

FIGURE 1

SCALE 0 1 2 MILES

0 1 2 3 KILOMETERS

APPROXIMATE

SOURCE:
1980 GENERAL HIGHWAY MAP AND
INFORMATION FROM SCS FIELD PERSONNEL
LAMBERT CONFORMAL CONIC PROJECTION

MARCH 1985 4-R-39100 5

INTRODUCTION

The purpose of this cooperative study is to identify flood hazard areas along the Heart River and South Branch of the Heart River in Stark County, North Dakota, and provide technical data necessary to implement an effective local flood plain management program. Increasing pressure to develop flood plain areas is becoming apparent as competition for land grows. Increasing land values and scarcity of undeveloped areas in which to expand often result in flood plain encroachment. Nonregulated development and encroachment frequently result in reduced flood conveyance, thereby increasing flood stages and overall flood losses.

Since the advent of federal laws governing financing within flood plains, many financial institutions are reluctant to lend and federal agencies cannot finance projects in these communities, unless there is assurance that the area is flood free or can be protected. Previous maps prepared for Federal Emergency Management Agency (FEMA) identified most of the city of South Heart in the flood zone.

It is imperative that flood plains in agricultural areas be defined so that the planning and location of valuable properties can be controlled and areas identified where future flood control measures can be applied.

This flood plain management study was requested by the city of South Heart, Stark County Water Resource District and the Western Soil Conservation District, through the North Dakota State Water Commission, under the 1978 Joint Coordination Agreement with the Soil Conservation Service. Priorities regarding such studies are set by the North Dakota State Water Commission. The study was carried out in accordance with the October 1983 Plan of Study between the city of South Heart, Stark County Water Resource District, Western Soil Conservation District, North Dakota State Water Commission and the Soil Conservation Service.

This Flood Plain Management Study consists of the Heart River and the South Branch of the Heart River . A total of 6.11 river miles were studied.

The Heart River Study begins at river mile 216.68 at the north-south quarter line of Section 7, T. 139 N., R. 97 W. and proceeds upstream to the west section line of Section 11, T. 139 N., R. 98 W. (River Mile 221.66)

The South Branch of the Heart River Study begins approximately 0.5 miles west of South Heart, ND (river mile 220.71 of the Heart River) and proceeds upstream along the South Branch of the Heart River 1.13 river miles to the east-west quarter line of Sections 13 and 14, T. 139 N., R. 98 W.

The "Fxtra Territorial Jurisdiction Law", passed by the 1975 North Dakota Legislature, provides communities with zoning authority outside the corporate limits. The 1981 North Dakota Legislature amended and re-enacted the law to include each quarter-quarter section within one-half mile of the corporate limits for incorporated cities with a population of 5,000 or less. The extra territorial jurisdiction for the city of South Heart is covered by this study.

Flood plain management studies carried out by the Soil Conservation Service result from recommendations found in A Report by the Task Force on Federal Flood Control Policy, House Document No. 464 (89th Congress, second session), Recommendation 9(c), "Regulation of Land Use."

SCS assists State agencies and communities in the development, revision, and implementation of their flood plain management programs by carrying out cooperative flood plain management studies (FPMS's) in accordance with Federal Level Recommendation 3 of "A Unified National Program for Flood Plain Management," and Section 6 of Public Law 83-566. The principles contained in Executive Order 11988, Floodplain Management, directs that "all executive agencies responsible for programs which entail land use planning shall take flood hazards into account when evaluating plans and shall encourage land use appropriate to the degree of hazard involved."

Potential users of flood plains should base planning decisions upon the advantages and disadvantages of each location. Potential flood hazards are often unknown and consequently the managers, potential users, and occupants cannot always accurately assess these risks. In order for a local flood plain management program to be effective in the planning, development and use of flood plains, it is necessary for SCS to:

1. Assist the state and local units of government by preparing appropriate technical information and interpretations for use in their flood plain management programs.

2. Provide technical services to managers of flood plain property for present and future land uses.

3. Improve basic technical knowledge about flood hazards in cooperation with other agencies and organizations.

This report contains aerial photomaps, water surface profiles and typical valley and channel cross sections indicating the extent of flooding which can be expected within the study areas. The 10-, 50-, 100- and 500-year frequency flood discharges and elevations are included. The hydraulic analyses for this study were based on unobstructed flow. The flow elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly and do not fail.

The North Dakota State Water Commission or the Soil Conservation Service will, upon request, provide technical assistance to federal, state and local agencies and organizations in the interpretation and use of the information contained in this study.

DESCRIPTION OF STUDY AREA

The Flood Plain Management Study Area is located in the state of North Dakota Hydrologic Unit 10130202. Drainage area contributing runoff to the study area is 264 square miles. (See Appendix E, page 34 for a breakdown of drainage areas and discharges.)

The temperature range within the study area has considerable variance from summer to winter, and on occasion from day to day. In the winter, outbreaks of arctic air brings bitter cold. Most winters have many days with temperatures below zero. The mean temperature for the winter months of December, January and February is 16.1°F. Summers are warm and pleasant. The average temperature for the summer months of June, July and August is 66.7°F. Average annual precipitation is about 16 inches.

The South Branch of the Heart River and the Heart River, which join at the city of South Heart, North Dakota, have their source in the non-glaciated uplands which form the watershed divide between the tributaries to the Missouri River and Little Missouri River. The eastward flowing tributaries which comprise the watershed above the town of South Heart, are as follows: South and North Fork Bull Creek, South Branch Heart River, Norwegian Creek, Heart River and Coal Mine Creek.

The streams flow in an alluvial valley whose sediments were derived from continental formation sediments. The formations include the Tertiary Paleocene Sentinel Butte fm, Eocene Golden Valley fm., and the Oligocene White River fm. Sediments range from weathered sandstone, shale, siltstone, claystone and lignite to bentonitic clay. This bentonitic clay is easily eroded and the runoff from these areas, especially into the South Heart River, has the appearance of cream.

NATURAL VALUES

Land use for the study area consists of agricultural, community services, farmstead, recreation, residential, transportation services, and wildlife land.

The agricultural land includes small grain and fallow cropland, rangeland, pastureland, hayland and farmsteads including associated structures and facilities. Thirty-four percent of the study area is prime farmland.

Community services, residential and transportation services land consists of streets, alleys, highways, railroads, underground and surface utility rights-of-way serving the town of South Heart.

Wildlife land uses in the study area consist of the Heart River channel, South Branch Heart River channel, and additional unnamed tributaries along with their associated riparian areas.

The flood plains, including approximately 26 acres of type 3 wetlands and 19 acres of type 1 wetlands, have the potential, with proper resource management, to provide high value habitat for wildlife species utilizing the study area. These high value habitat areas can furnish breeding, escape, and rearing habitat for big and small game, furbearers and other wildlife; spawning and nursery areas for fishes, amphibians and aquatic invertebrates; and a high yield food source for many resident and migratory species.

Portions of the western half of the study unit have riparian resources that are being damaged due to intensive livestock utilization. The eastern part of the study area has resource deterioration due to encroachment on the riparian buffer zones by cropland operations. These operations have reduced the ability of the flood plains to provide an extremely valuable, renewable resource important to economic welfare, enjoyment, and physical well-being.

Because riparian areas within the flood plain serve as a buffer zone between aquatic and non aquatic environments and provide high value fish and wildlife habitat, these areas need to be protected and restored. Proper resource management on all land uses is beneficial to any life form now and for the future.

There are no portions of the study area listed nor proposed to be listed in the National Wild and Scenic Rivers System. No critical habitat for threatened and endangered species was identified in the study area.

The 1978 Stream Evaluation Map State of North Dakota classifies the study area as class III (a substantial fishery resource).

FLOOD HISTORY

Most of the flooding occurs in the spring of the year, usually in March or April. Large floods occur from spring snowmelt runoff due to winter accumulation of snow and frozen soil conditions. Figure 2 shows a photograph of the March 1943 flood. No gage data or reliable high water marks are available to determine a frequency for this event. Large floods in recent years occurred in March 1943, May 1970 and March 1978.

FLOOD POTENTIAL

Potential flood areas within the study area include primarily agricultural land. Flood damages include eroded land, sediment deposition, washed out fences, and weakened roads and bridges.

Restrictive bridges, dense vegetation and sharp meanders in the channel all contribute to the severity of flooding within the flood plain.

Floodwaters in the Heart River rise rapidly. Duration of flooding normally ranges from 2 to 6 days for significant flood events.

A 500-year frequency flood within the study area will inundate approximately 850 acres and a 100-year frequency flood will inundate approximately 800 acres. Flooding occurs in and around the city of South Heart. There are six out buildings in the 100-year frequency flood and two mobile homes identified in the 500-year frequency flood plains.

Figures 3 through 6 show potential flood stages at various locations of the study area.

FLOOD PLAIN MANAGEMENT

The city and county can minimize future flood losses by planning for the protection, wise use and orderly development outside the flood plain area with this flood hazard information. The overall plans of the community for industrial, commercial and residential areas, streets, utilities, and schools must recognize the need to develop outside the flood plain.

A coordinated planning procedure such as this is a vital part of any comprehensive flood plain management program. Effective flood plain management involves public policy and action for the wise use and development of the flood plain. It also includes such measures as collection and dissemination of flood control information, acquisition of flood plain lands, construction of control structures and enactment of ordinances and statutes regarding flood plain land use and development.

A viable local flood plain management program is comprised of numerous elements, some of which are: structural flood control works to protect existing development; regulations to guide new development; flood insurance to compensate damages on existing and new buildings; and individual protection measures such as flood proofing.

Flood Control Measures

Various structural flood control measures to reduce the flooded area include enlarged bridge openings, dikes, floodwater retarding dams, floodways and channel work, or a combination of the above.

Flood Plain Regulations

Flood plain regulations are designed to permit realistic use of flood plain areas without increasing potential damage. Among the various elements used to accomplish this are zoning ordinances, subdivision regulations, building codes, and sanitary and utility regulations. For a guide, see "A Perspective on Flood Plain Regulations for Flood Plain Management", Corps of Engineers' Manual EP 1165-2-3-4.

Flood Insurance

Under the National Flood Insurance Act of 1969 (PL 90-448), the Federal Emergency Management Agency (FEMA), Federal Insurance Administration (FIA), is authorized to carry out a National Flood Insurance Program (NFIP), which makes flood insurance coverage available to all walled and roofed structures and their contents used for residential, business, religious and agricultural purposes, buildings occupied by nonprofit organizations and those owned by state or local governments or their agencies. The city of South Heart currently participates in the Emergency Flood Insurance program.

The flood insurance rates and needs for the residence of South Heart will change dramatically because of this Flood Plain Management Study. The previous map used for the Emergency Flood Insurance Program showed most of the city in the flood plain. The previous map was based on visual observation, no hydraulic or hydrologic studies were involved. This study removes almost all of the city from the flood plain. The picture on page 11 shows standing water

in the foreground, apparently this was caused by lack of adequate internal drainage during the flood of 1943.

The unincorporated areas of Stark County currently participate in the National Flood Insurance Program. In this area, owners and occupiers of all buildings and mobile homes are eligible to obtain flood insurance coverage; and it is recommended that persons within or adjacent to the delineated flood hazard areas maintain flood insurance on both the structure and contents.

Further inquiries about the flood insurance program should be directed to the Office of the State Engineer, North Dakota State Water Commission; the official state coordinating agency for flood insurance.

Other Measures

Land use and other regulatory controls including zoning, subdivision regulation and building codes play an important role in flood plain management. In order for these measures to be effective, it is important that the community takes action to implement other programs and measures to supplement these controls. A few possible measures to protect and control developments in flood prone areas are: (1) open space land acquisition programs, (2) preferential tax assessment, and (3) public policy governing the construction of utilities and public facilities such as bridges and streets.

The Office of the State Engineer, upon request, will provide assistance in flood proofing techniques, the implementation of a flood warning system and establishment of a local flood data collection program.

Recommendations

Some specific recommendations for alleviating the flood situation along the flood plains of the Heart River and the South Branch of the Heart are:

1. Adoption of local land use and zoning regulations for all flood plain areas. The basic purpose of flood plain regulations is to control development on the flood plain consistent with nature's needs for conveyance of flood flows.

2. Flood proofing existing or future buildings that otherwise cannot be adequately protected. (See U.S. Army Corps of Engineers "Manual of Flood Proofing Regulations", EP 1165 2 314 and "Elevated Residential Structures Reducing Flood Damage Through Building Design: A Guide Manual", published by the Federal Insurance and Hazard Division, HUD).

3. Using as much of the flood hazard areas as possible for parks and other open space uses.

4. Installation of a dike system adjacent to the South Branch of the Heart River overflow area near the southwest part of the city.

5. Increase the areas of bridge and culvert openings to minimize the restriction of large floods.

6. Improve hydraulic characteristics of channels through an active maintenance program of clearing and snagging consistent with environmental guidelines.

7. Construct upstream floodwater retarding dams, as feasible, to retard flood flows. Two floodwater retarding dams are in the planning stage for the proposed Belfield Watershed which is approximately 14 miles upstream from the city of South Heart.

Figure 2 - March 1943 flood looking southwest from grain elevator. Photo by Henry Van Hoof

Figure 3 - M0.50 in Section 14, T. 139 N., R. 98 W. on South Branch Heart River

Figure 4 - M0.50 between Sections 12 and 13, T. 139 N., R. 98 W., on South Branch Heart River

Figure 5 - M219.31 approximately 800 feet north of the Heart River bridge on County Hwy 4511

Figure 6 - Low point on Broadway between 4th and 5th streets

APPENDIX A

SOILS

The soil information in this report is for only the flood plain area. The soils of Stark County are mapped, described, and interpreted in greater detail in the "Soil Survey of Stark County, North Dakota." Copies of this survey and help in using soil information are available from the local Soil Conservation Service Office in Dickinson, North Dakota.

Interpretations are given in Table I for a number of uses.

Yield Per Acre

The average yields per acre that can be expected of spring wheat under a high level of management are shown in the table. In any given year, yields may be higher or lower than those indicated in the table because of variations in rainfall and other climatic factors.

The yields are based mainly on the experience and records of farmers, conservationists, and extension agents. Available yield data from nearby counties and results of field trials and demonstrations are also considered.

The management needed to obtain the indicated yields of the various crops depends on the kind of soil and the crop. Management can include drainage, erosion control, and protection from flooding; proper planting and seeding rates; use of suitable high-yielding crop varieties; appropriate and timely tillage; control of weeds, plant diseases, and harmful insects; favorable soil reaction and optimum levels of nitrogen, phosphorus, potassium, and trace elements for each crop; effective use of crop residue, barnyard manure, and green-manure crops; and timely harvesting that insures highest profits. Dashes indicated crops not grown or not suited to the soil.

Land Capability Classification

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The grouping does not take into account major and generally

expensive landforming that would change slope, depth, or other characteristics of the soils, nor does it consider possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, woodland or engineering purposes.

In the capability system, soils are generally grouped at three levels: capability class, subclass and unit. Only class and subclass are used in this survey. These levels are defined in the following paragraphs.

Capability classes, the broadest groups, are designated by Roman numberals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class I soils have slight limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or require special conservation practices or both.

Class III soils have severe limitations that reduce the choice of plants or require special conservation practices or both.

Class IV soils have very severe limitations that reduce the choice of plants or require very careful management or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use.

Class VI soils have severe limitations that make them generally unsuitable for cultivation.

Class VII soils have very severe limitations that make them unsuitable for cultivation.

Class VIII soils have limitations that essentially preclude their use for commercial crop production.

Capability subclasses are soil groups within one class. They are designated by adding a small letter e, w, s, or c to the class numeral, for example, IIe.

The letter e shows that the main limitation is risk of erosion unless closegrowing plant cover is maintained; w shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); s shows that the soil is limited mainly because it is shallow, droughty, or stony; and c, used in only some parts of the United States, shows that the chief limitation is climate that if very cold or very dry.

In Class I there are no subclasses because the soils of this class have few limitations. Class V contains only the subclasses indicated by w, s or c because the soils in Class V are subject to little or no erosion. They have other limitations that restrict their use to pasture, rangeland, woodland, wildlife habitat or recreation.

Important Farmland

Prime farmland is one of several kinds of important farmlands defined by the U.S. Department of Agriculture. It is of major importance in providing the nation's short and long-range needs for food and fiber. Prime farmland is the land best suited to producing food, feed, forage, fiber and oilseed crops. Prime farmland may be in pasture, crops, woodland or other land but is is not urban or built up land or water areas.

Additional Farmland of Statewide Importance (AFSI) is land, in addition to prime farmlands, that is of statewide importance for the production of food, feed, fiber, forage, and oilseed crops. Generally, additional farmlands of statewide importance include those that are nearly prime farmland and that

economically produce high yields of crops when treated and managed according to acceptable farming methods. Some may produce as high a yield as prime farmlands if conditions are favorable.

Additional Farmlands of Local Importance are lands not designated prime or Additional Farmlands of Statewide Importance (AFSI) that can be protected from erosion and are capable of sustained production of the commonly grown crops. Additional Farmlands of Local Importance are designated by a unit of local government. The term "unit of local government" means the government of a county, municipality, town, township, village, or other unit of general government below the state level, or a combination of units of local government acting through an area-wide agency under state law or an agreement for the formulation of regional development policies and plans.

Soil Uses and Limitations

The soils are rated in Table I according to limitations that affect their suitability for playgrounds, picnic areas, dwellings with basements, septic tank absorption fields, sewage lagoons, fill materials for embankments and topsoil. The ratings are based on restrictive soil features such as wetness, slope and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, is the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to water, potential water impoundment sites and access to public sewerlines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation are also important. Soils subject to flooding are limited for recreations use by the duration and intensity of flooding and the season when flooding occurs. In planning recreation facilities, on site assessment of the height, duration, intensity and frequency of flooding is essential.

The degree of soil limitation is expressed as slight, moderate or severe. Slight means that soil properties are generally favorable and that limitations can be overcome or alleviated by planning, design or special maintenance. Severe means that soil properties are unfavorable and that limitations can be offset only by costly soil reclamation, special design, intensive maintenance, limited use or by a combination of these measures.

Dwellings

Ratings are made for small dwellings with basements on undisturbed soil. The ratings are based on soil properties, site features and observed performance of the soils. A high water table, flooding, shrink-swell potential and organic layers can cause the movement of footings. A high water table, depth to bedrock or to a cemented pan, large stones and flooding affect the ease of excavation and construction. Landscaping and grading that require cuts and fills of more than 5 to 6 feet are not considered.

Septic Tank Absorption Fields

Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Only that part of the soil between depths of 24 to 72 inches is evaluated. The ratings are based on soils properties, site features and observed performance of the soils. Permeability, a high water table, depth to bedrock or a cemented pan, and flooding affect absorption of the effluent. Large stones and bedrock, or a cemented pan interfere with installation.

Playgrounds

Playgrounds require soils that can withstand intensive foot traffic. The best soils are almost level and are not wet or subject to flooding during the

season of use. The surface is free of stones and boulders, is firm after rains and is not dusty when dry. If grading is needed, the depth of the soil over bedrock or a hardpan should be considered.

Picnic Areas

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The best soils for picnic areas are firm when wet, are not dusty when dry, are not subject to flooding during the period of use and do not have slopes, stones or boulders that increase the cost of shaping sites or of building access roads and parking areas.

Sewage Lagoons

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons should have a nearly level floor surrounded by cut slopes or embankments of compacted soil. Lagoons generally are designed to hold the sewage within a depth of 2 to 5 feet. Nearly impervious soil material for the lagoon floor and sides is required to minimize seepage and contamination of ground water.

The table gives ratings for the natural soil that makes up the lagoon floor. The surface layer and generally 1 to 2 feet of soil material below the surface layer are excavated to provide material for the embankments. The ratings are based on soil properties, site features and observed performance of the soils. Considered in the ratings are slope, permeability, a high water table, depth to bedrock or to a cemented pan, flooding, large stones and content of organic matter.

Excessive seepage due to rapid permeability of the soil or a water table that is high enough to raise the level of sewage in the lagoon causes a lagoon to function unsatisfactorily. Pollution results if seepage is excessive or if floodwater overtops the lagoon. A high content of organic matter is detrimental to proper functioning of the lagoon because it inhibits aerobic activity. Slope, bedrock and cemented pans can cause construction problems and large stones can hinder compaction of the lagoon floor.

Embankment, Dikes, and Levees

Embankment, dikes and levees are raised structures of soil material constructed to impound water or to protect land against overflow. In this table, the soils are rated as a source of fill material below the surface layer to a depth of about 5 feet. It is assumed that soil layers will be uniformly mixed and compacted during construction.

The ratings do not indicate the ability of the natural soil to support an embankment. Soil properties to a depth even greater than the height of the embankment can affect performance and safety of the embankment. Generally, deeper onsite investigation is needed to determine these properties.

Soil material in embankments must be resistant to seepage, piping and erosion, and have favorable compaction characteristics. Unfavorable features include less than 5 feet of suitable material and a high content of stones or organic matter, salts or sodium. A high water table affects the amount of usable material.

Topsoil

Topsoil is used to cover an area so that vegetation can be established and maintained. The upper 40 inches of a soil is evaluated for use as topsoil. Also evaluated is the reclamation potential of the borrow area.

Plant growth is affected by toxic material and by such properties as soil reaction, available water capacity and fertility. The ease of excavating, loading and spreading is affected by rock fragments, slope, water table, soil texture and thickness of suitable material. Reclamation of the borrow area is affected by slope, water table, rock fragments, bedrock and toxic material.

Soils rated good have friable loamy material to a depth of at least 40 inches. They are free of stones and cobbles, have little or no gravel and have slopes of less than 8 percent. They are low in content of soluble salts, are naturally fertile or respond well to fertilizer and are not so wet that excavation is difficult.

Soils rated fair are sandy soils; loamy soils that have a relatively high content of clay; soils that have only 20 to 40 inches of suitable material; soils that have an appreciable amount of gravel, stones, or soluble salts; or soils that have slopes of 8 to 15 percent. The soils are not so wet that excavation is difficult.

Soils rated poor are very sandy or clayey; have less than 20 inches of suitable material; have a large amount of gravel, stones or soluble salts; have slopes of more than 15 percent; or have a seasonal water table at or near the surface.

The surface layer of most soils is generally preferred for topsoil because of its organic matter content. Organic matter greatly increases the absorption and retention of moisture and nutrients for plant growth.

SOUTH HEART FLOOD PLAIN MANAGEMENT STUDY
STARK COUNTY, NORTH DAKOTA
TABLE I: SOIL INTERPRETATIONS FOR SELECTED USES

Soil Symbol	Soil Name	Capability Class and Subclass	Important Farmland 1/ 2/ Category	Spring Wheat 3/ Yield Bu/Ac	Dwellings 1/ With Basements 4/	Septic Tank 1/ Absorption Fields 1/	Playgrounds 1/	Picnic Areas 1/	Sewage Lagoons 1/ 4/	Dikes, Levees, 1/ Embankments	Topsoil 1/
BaD	Bainville and Midway soils, steep		0	-							
	Bainville	VIe			Severe - Depth to Rock, Slope	Severe - Depth to Rock	Severe - Slope, Depth To Rock	Severe - Slope, Depth to Rock	Severe - Depth To Rock	Severe - Piping	Poor - Area Reclaim, Small Stones, Slope
	Midway	VIe			Severe - Depth to Rock, Slope, Shrink-Swell	Severe - Depth to Rock	Severe - Slope, Depth To Rock	Severe Slope Depth to Rock	Severe - Depth to Rock	Severe - Thin Layer	Poor - Area Reclaim Slope
BoA	Belfield-Rhoades loams, level		AFL1	17							
	Belfield	IIIs			Severe - Shrink-Swell	Severe - Perco Slowly	Severe - Excess Sodium	Severe - Excess Sodium	Slight	Severe - Excess Sodium	Poor - Excess Sodium
	Rhoades	VIs			Severe - Shrink-Swell	Severe - Perco Slowly	Severe - Excess Sodium	Severe - Excess Sodium	Moderate - Depth To Rock	Severe - Excess Sodium	Poor - Excess Sodium
BrA	Belfield-Rhoades silty clay loams, level		AFL1	16							
	Belfield	IIIe			Severe - Shrink-Swell	Severe - Perco Slowly	Severe - Excess Sodium	Severe - Excess Sodium	Slight	Severe - Excess Sodium	Poor - Excess Sodium
	Rhoades	VIs			Severe - Shrink-Swell	Severe - Perco Slowly	Severe - Excess Sodium	Severe - Excess Sodium	Moderate - Depth to Rock	Severe - Excess Sodium	Poor - Excess Sodium
CbC	Chama-Bainville loams, sloping		0	16							
	Chama	IVe			Moderate - Depth to Rock, Shrink-Swell	Severe - Depth to Rock	Severe - Slope	Slight	Severe - Depth to Rock	Severe - Piping	Fair - Area Reclaim, Thin Layer
	Bainville	IVs			Severe - Depth to Rock	Severe - Depth to Rock	Severe - Slope, Depth to Rock	Severe - Depth To Rock	Severe - Depth to Rock	Severe - Piping	Poor - Area Reclaim Small Stones
CbD	Chama-Bainville loams, steongly sloping		0	-							
	Chama	VIe			Moderate - Depth to Rock, Slope, Shrink-Swell	Severe - Depth to Rock	Severe - Slope	Moderate - Slope	Severe - Depth to Rock, Slope	Severe - Piping	Fair - Area Reclaim, Thin Layer, Slope
	Bainville	VIe			Severe - Depth to Rock	Severe - Depth to Rock	Severe - Slope, Depth to Rock	Severe - Depth to Rock	Severe - Depth to Rock, Slope	Severe - Piping	Poor - Area Reclaim, Small Stones
Dk	Olmstck clay	IIIw	0	22	Severe - Ponding, Shrink-Swell	Severe - Ponding, Perco Slowly	Severe - Too Clayey, Piping, Perco Slowly	Severe - Piping, Too Clayey, Perco Slowly	Severe - Ponding	Severe - Hard to Pack, Ponding	Poor - Too Clayey, Wetness
FaB	Farland silt loam, gently sloping	IIe	AFS1	25	Moderate - Shrink-Swell	Severe - Perco Slowly	Moderate - Slope	Slight	Moderate - Seepage, Slope	Severe - Piping	Fair - Thin Layer
FgA	Farland, Aanegard & Crail silt loams, level		AFS1	26							
	Farland	IIc			Moderate - Shrink-Swell	Severe - Perco Slowly	Slight	Slight	Moderate - Seepage	Severe - Piping	Fair - Thin Layer
	Aanegard	IIc			Slight	Moderate - Perco Slowly	Slight	Slight	Moderate - Seepage	Severe - Piping	Good
	Crail	IIc			Moderate - Shrink-Swell	Severe - Perco Slowly	Slight	Slight	Slight	Moderate - Piping, Hard to Pack	Poor - Thin Layer

TABLE I: continued

Soil Symbol	Soil Name	Capability Class and Subclass	Important Farmland Category [2]	Spring Wheat Yield Bu/Ac [3]	Dwellings With Basements [4]	Septic Tank Absorption Fields [4]	Playgrounds [4]	Picnic Areas [4]	Sewage Lagoons [4]	Dikes, Levees, Embankments [4]	Topsoil [4]
Fr	Flasher-Rock outcrop complex		0	-							
	Flasher	VIIe			Severe - Depth to Rock; Slope	Severe - Depth to Rock, Slope	Severe - Slope, Depth To Rock	Severe - Slope, Depth To Rock	Severe - Slope, Depth To Rock	Slight	Poor - Area Reclaim, Slope
	Rock outcrop	--			-----	-----					
Ga	Gallatin clay loam	IIw	0		Severe - Flooding	Severe - Flooding	Severe - Flooding	Moderate - Flooding, Wetness	Severe - Flooding	Severe - piping	Good
Gv	Gravelly land	VIIs	0		Severe - Slope	Severe - Slope, Poor Filter	Severe - Slope	Severe - Slope	Severe - Seepage, Piping	Severe - Seepage, Slope	Poor - Small Stones, Slope, Area Reclaim
Ha	Havre loam	IIc	AFSI	26	Severe - FLooding	Severe - Flooding	Moderate - Flooding	Moderate Flooding	Severe - Flooding	Severe - Piping	Good
He	Havre silty clay loam	IIc	AFSI	26	Severe - Flooding	Severe - Flooding	Moderate - Flooding	Moderate - Flooding	Severe - Flooding	Sever - Piping	Fair - Too Clayey
HcA	Hanning fine sandy loam, level	IIIs	0	14	Slight	Severe - Poor Filter	Slight	Slight	Severe - Seepage	Severe - Seepage	Poor - Small Stones, Area Reclaim
HcB	Hanning fine sandy loam, Gently sloping	IIIs	0	11	Slight	Severe - Poor Filter	Moderate - SLope	Slight	Severe - Seepage	Severe - Seepage	Poor - Small Stones, Area Reclaim
HeB	Moreau silty clay, gently sloping	IIIe	0	17	Severe - Shrink-Swell	Severe - Depth to Rock; Perce Slowly	Moderate - SLope, Too Clayey	Moderate - Too Clayey	Severe - Depth To Rock	Severe - Hard to Pack	Poor - Too Clayey
HsB	Morton & Farland silt loams, gently sloping		AFSI	25							
	Morton	IIe			Moderate - Depth to Rock, Shrink-Swell	Severe - Depth to Rock	Moderate - Slope, Depth To Rock	Slight	Severe - Depth To Rock	Severe - Piping	Fair - Area Reclaim, Thin Layer
	Farland	IIe			Moderate - Shrink-Swell	Severe - Perce Slowly	Moderate - Slope	Slight	Moderate - Seepage	Severe - Piping	Fair - Thin Layer
MtB	Morton-Rhoades loam, gently sloping		AFLI	14							
	Morton	IIe			Moderate - Depth to Rock; Shrink-Swell	Severe - Depth to Rock	Moderate - Slope, Depth To Rock	Slight	Severe - Depth To Rock	Severe - Piping	Fair - Area Reclaim, Thin Layer
	Rhoades	VIs			Severe - Shrink-Swell	Severe - Perce Slowly	Severe - Excess Sodium	Severe - Excess Sodium	Moderate - Depth To Rock; Slope	Severe - Excess Sodium	Poor - Excess Sodium
PaA	Parshall fine sandy loam, level	IIIe	AFSI	21	Slight	Slight	Slight	Slight	Severe - Seepage	Severe - Piping	Good
PrA	Promise silty clay, level	IIs	AFSI	26	Severe - Shrink-Swell	Severe - Perce Slowly	Moderate - Too Clayey	Moderate - Too CLayey	Slight	Moderate - Hard To Pack	Poor - Too Clayey
RgB	Regent-Moreau silty clay loams, Gently sloping		AFLI	15							
	Regent	IIe			Severe - Shrink-Swell	Severe - Depth to Rock, Perce Slowly	Moderate - Slope	Slight	Severe - Depth To Rock	Severe - Hard To Pack	Fair - Too Clayey
	Moreau	IIIe			Severe - Shrink-Swell	Severe - Depth to Rock, Perce Slowly	Moderate - Slope	Slight	Severe - Depth To Rock	Severe - Hard To Pack	Fair - Area Reclaim, Too Clayey

TABLE 1: continued

Soil Symbol	Soil Name	Capability Class and Subclass	Important Farmland 1/ Category 2/	Spring Wheat Yield Bu/Ac 3/	Dwellings 1/ With Basements 4/	Septic Tank 1/ Absorption Fields 1/	Playgrounds 1/	Picnic Areas 1/	Sewage Lagoons 1/ 4/	Dikes, Levees, 1/ Embankments	Topsoil 1/
RsA	Rhoades & Belfield soils, level		0	-							
	Rhoades	VIs			Severe - Shrink-Swell	Severe - Percs Slowly	Severe - Excess Sodium	Severe - Excess Sodium	Moderate - Depth to Rock	Severe - Excess Sodium	Poor - Excess Sodium
	Belfield	IIIs			Severe - Shrink-Swell	Severe - Percs Slowly	Severe - Excess Sodium	Severe - Excess Sodium	Slight	Severe - Excess Sodium	Poor - Excess Sodium
RsB	Rhoades & Belfield soils, gently sloping		0	-							
	Rhoades	VIs			Severe - Shrink-Swell	Severe - Percs Slowly	Severe - Excess Sodium	Severe - Excess Sodium	Moderate - Depth To Rock, Slope	Severe - Excess Sodium	Poor - Excess Sodium
	Belfield	IIIs			Severe - Shrink-Swell	Severe - Percs Slowly	Severe - Excess Sodium	Severe - Excess Sodium	Moderate - Slope	Severe - Excess Sodium	Poor - Excess Sodium
Se	Saline Alluvial Land	VIs	0	-	Severe - Flooding, Wetness	Severe - Flooding, Wetness, Percs Slowly	Severe - Wetness, Percs Slowly, Excess Sodium	Severe - Wetness, Excess Sodium, Percs Slowly	Severe - Flooding, Wetness	Severe - Piping, Wetness, Excess Sodium	Poor - Wetness, Excess Sodium
Sg	Savage silty clay loam	IIs	AFS1	27	Severe - Shrink-Swell	Severe - Percs Slowly	Slight	Slight	Slight	Moderate - Piping	Poor - Thin Layer
StA	Straw loam, level	IIc	P	29	Severe - Flooding	Moderate - Flooding, Percs Slowly	Slight	Slight	Severe - Seepage, Flooding	Severe - Piping	Good
Sv	Straw & Havre soils, channeled		0	-							
	Straw	VIs			Severe - Flooding	Moderate - Flooding, Percs Slowly	Slight	Slight	Severe - Seepage, Flooding	Severe - Piping	Good
	Havre	VIs			Severe - Flooding	Moderate - Flooding, Percs Slowly	Slight	Slight	Moderate - Seepage	Severe - Piping	Good
We	Wet Alluvial Land	Vw	0	-	Severe - Flooding, Wetness	Severe - Flooding, Wetness	Severe - Flooding, Wetness	Severe - Wetness	Severe - Flooding Wetness	Severe - Piping, Wetness	Poor - Wetness
Wb	Wibaux soils	VIIs	0	-	Severe - Large Stones	Severe - Poor Filter, Large Stones	Severe - Slope, Small Stones	Severe - Small Stones	Severe - Seepage, Slope, Large Stones	Severe - Seepage, Large Stones	Poor - Small Stones, Area Reclaim

1/ Soil Interpretations Stark County, North Dakota prepared by USDA SCS, 1980.

2/ P=prime, AFS1=additional farmlands of statewide importance, AFL1=additional farmlands of local importance, 0=other land.

3/ All yields are for drained areas of the poorly drained and very poorly drained soils.

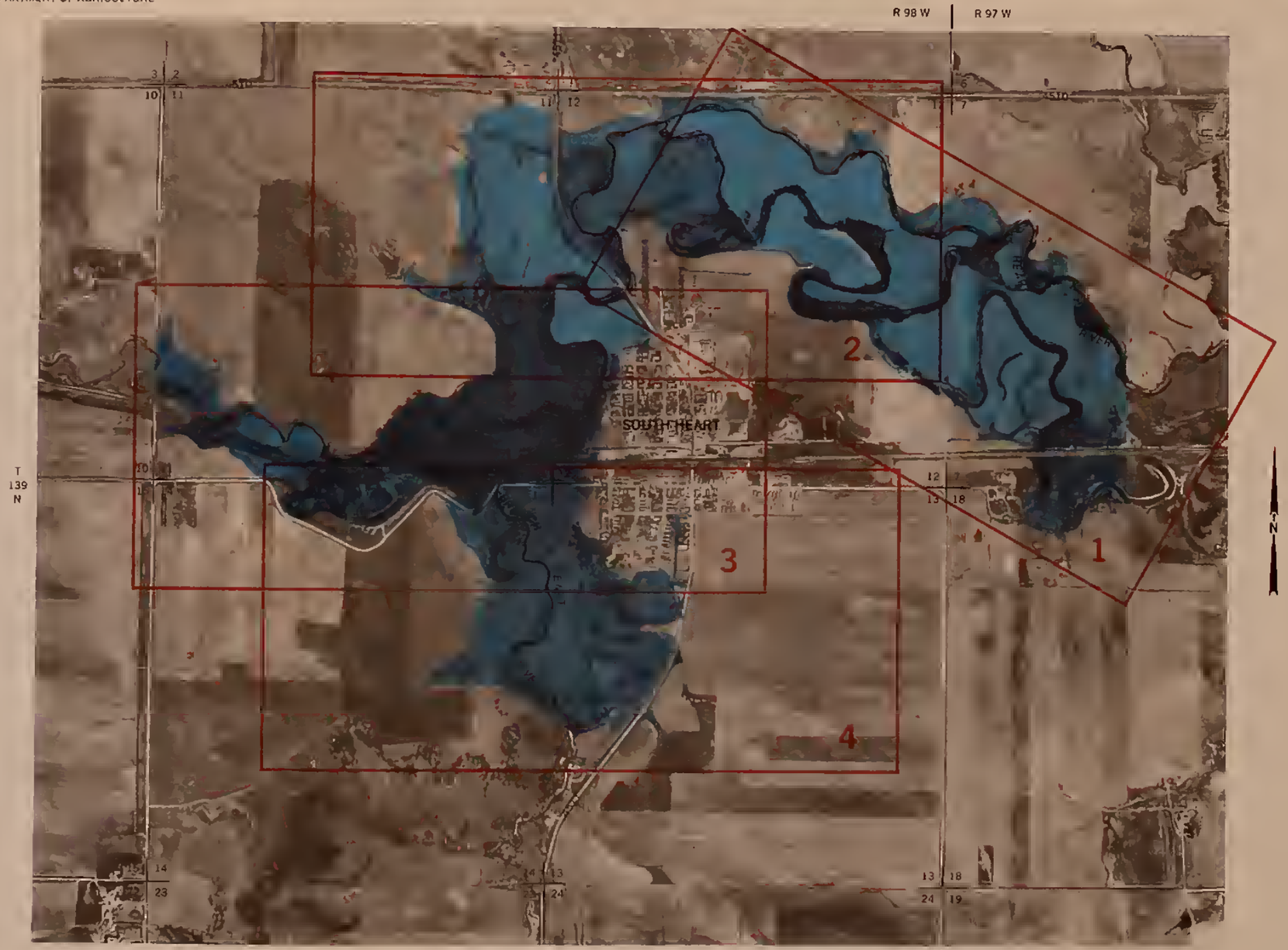
4/ Construction of dwellings, septic tanks and sewage lagoons is not recommended in the floodplain. However, if construction is necessary the developer should consider the flood hazard and soil restrictions presented in this report.

FLOOD HAZARD AREA PHOTOMAPS

APPENDIX B

U.S. DEPARTMENT OF AGRICULTURE

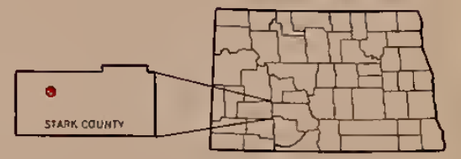
SOIL CONSERVATION SERVICE



LEGEND

- 1 — SHEET COVERAGE
- FLOOD PLAIN AREA (100 AND 500 YEAR FREQUENCY FLOODS)
- STREAM CHANNEL

NORTH DAKOTA



INDEX TO MAP SHEETS

SOUTH HEART

FLOOD PLAIN MANAGEMENT STUDY

STARK COUNTY, NORTH DAKOTA

SCALE 0 ¼ ½ ¾ 1 MILE
0 ½ 1 KILOMETER
APPROXIMATE

SOURCE
OCTOBER 1983 AERIAL PHOTOGRAPHY FROM KBM, INC
AND INFORMATION FROM SCS FIELD PERSONNEL

MARCH 1985 4-R 39100-2

LEGEND

- 100 YEAR FREQUENCY FLOOD (1% CHANCE FLOOD)
- 500 YEAR FREQUENCY FLOOD
- STREAM CHANNEL
- M 0.80 — VALLEY SECTION
- 2460 — ESTIMATED 100-YEAR FLOOD ELEVATION
- BrA — SOILS AREA & SYMBOLS
- RM 23 — REFERENCE MARK

SCALE 0 400 800 FEET; 0 100 200 METERS; APPROXIMATE

SOURCE
OCTOBER 1993 AERIAL PHOTOGRAPHY FROM KBM, INC AND INFORMATION FROM SCS FIELD PERSONNEL

SHEET 1 OF 4

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

FLOOD PLAIN MANAGEMENT STUDY
STARK COUNTY, NORTH DAKOTA

FLOOD HAZARD AREA

SOUTH HEART

MARCH 1985 4-R-39100

LEGEND

- 100 YEAR FREQUENCY FLOOD (1% CHANCE FLOOD)
- 500 YEAR FREQUENCY FLOOD
- STREAM CHANNEL
- M 0.80 — VALLEY SECTION
- 2460 — ESTIMATED 100-YEAR FLOOD ELEVATION
- RgB — SOILS AREA & SYMBOLS
- RM 23 — REFERENCE MARK

SCALE 0 400 800 FEET; 0 100 200 METERS APPROXIMATE

SOURCE
OCTOBER 1983 AERIAL PHOTOGRAPHY FROM KDM, INC AND INFORMATION FROM SCS FIELD PERSONNEL

SHEET 2 OF 4

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

FLOOD PLAIN MANAGEMENT STUDY
STARK COUNTY, NORTH DAKOTA

FLOOD HAZARD AREA

SOUTH HEART

LEGEND

- 100 YEAR FREQUENCY FLOOD (1% CHANCE FLOOD)
- 500 YEAR FREQUENCY FLOOD
- STREAM CHANNEL
- M 0.80 — VALLEY SECTION
- 2460 — ESTIMATED 100-YEAR FLOOD ELEVATION
- RgB — SOILS AREA & SYMBOLS
- RM 23 — REFERENCE MARK

SCALE 0 400 800 FEET; 0 100 200 METERS — APPROXIMATE

SOURCE
OCTOBER 1983 AERIAL PHOTOGRAPHY FROM KBM, INC AND INFORMATION FROM SCS FIELD PERSONNEL

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

FLOOD PLAIN MANAGEMENT STUDY
STARK COUNTY, NORTH DAKOTA

FLOOD HAZARD AREA

SOUTH HEART

SHEET 3 OF 4

MARCH 1985 4 R 39100

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

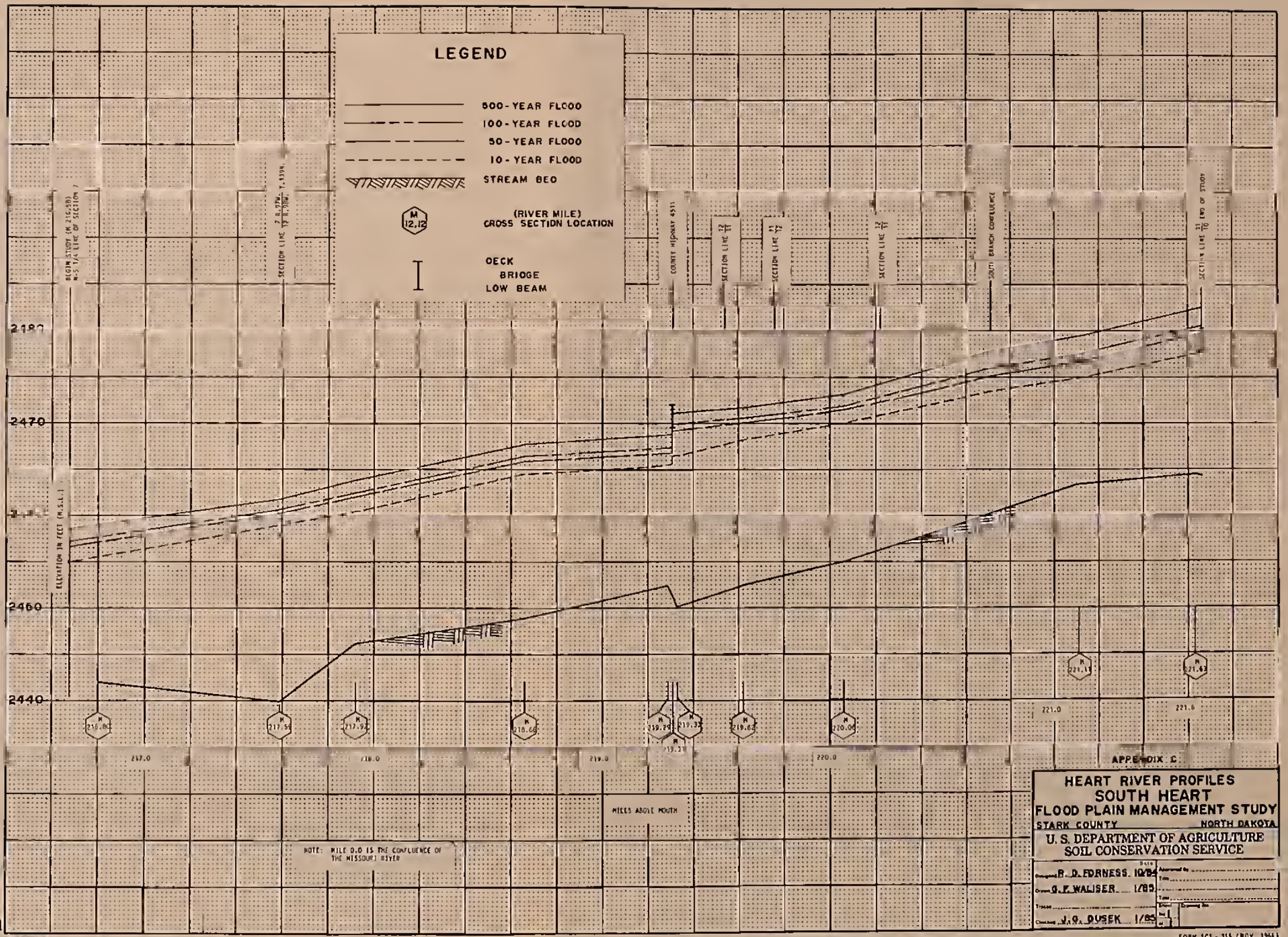
FLOOD PLAIN MANAGEMENT STUDY
STARK COUNTY, NORTH DAKOTA

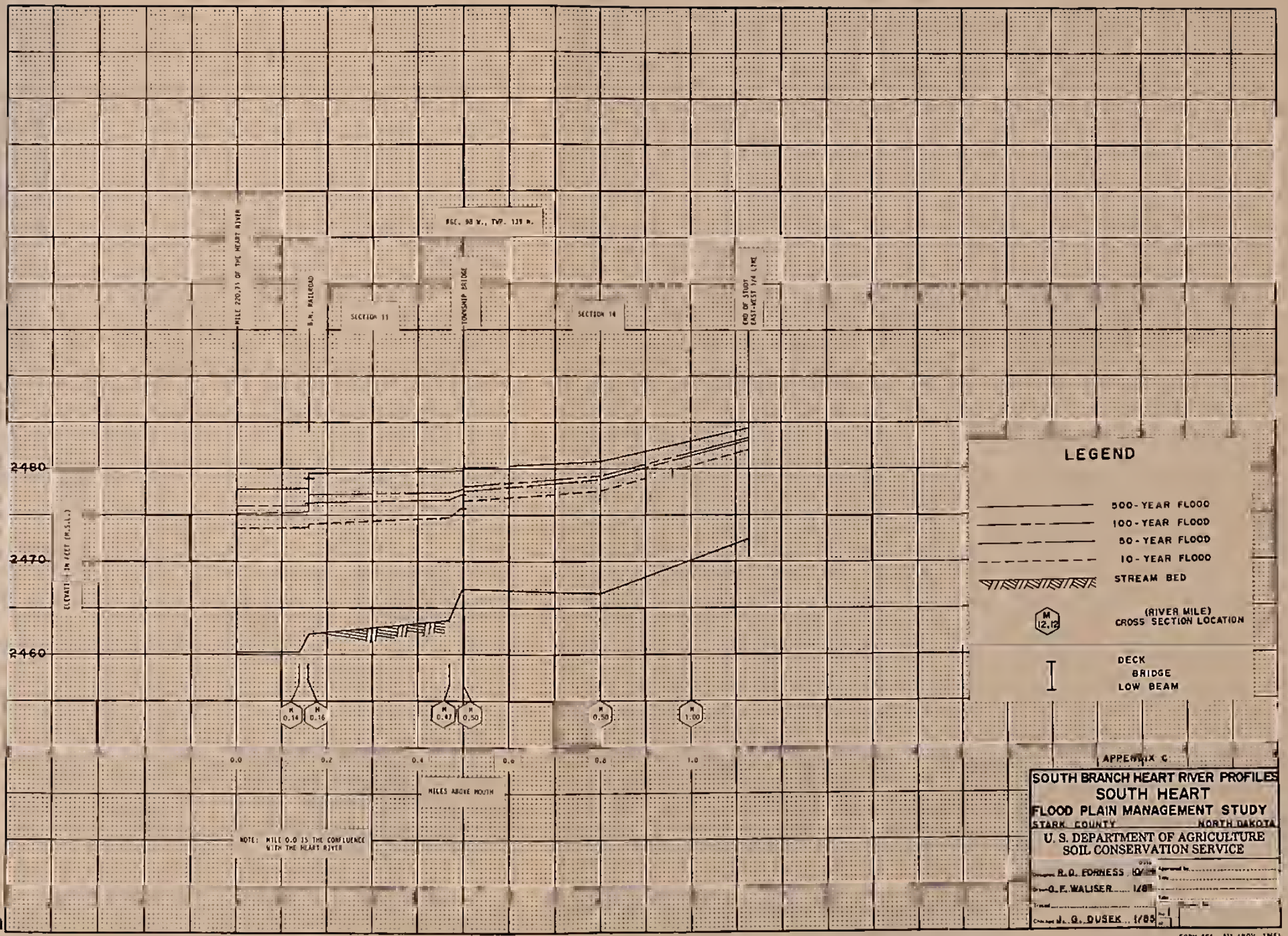
FLOOD HAZARD AREA

SOUTH HEART

SHEET 4 OF 4

MARCH 1985 4-R-39100


LEGEND
500-YEAR FLOOD
100-YEAR FLOOD
50-YEAR FLOOD
10-YEAR FLOOD
STREAM BED
(RIVER MILE) CROSS SECTION LOCATION
DECK BRIDGE LOW BEAM
BEGIN STUDY (N 215.58) N-S 1/4 LINE OF SECTION 7
SECTION LINE 7 T.139N. R.79W. 12 T.139N. R.78W.
COUNTY HIGHWAY 4515
SECTION LINE 12 11
SECTION LINE 11 12
SECTION LINE 12 11
SOUTH BRANCH CONFLUENCE
SECTION LINE 11 10 END OF STUDY
ELEVATION IN FEET (M.S.L.)
2480
2470
2460
2440
M 216.82
M 217.59
M 217.92
M 218.68
M 219.29
M 219.33
M 219.82
M 220.06
M 221.11
M 221.63
217.0
218.0
219.0
220.0
221.0
221.5
MILES ABOVE MOUTH
NOTE: MILE 0.0 IS THE CONFLUENCE OF THE MISSOURI RIVER
APPENDIX C
HEART RIVER PROFILES
SOUTH HEART
FLOOD PLAIN MANAGEMENT STUDY
STARK COUNTY NORTH DAKOTA
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Designed R. D. FORNESS. 10/84
Drawn G. F. WALISER 1/85
Traced
Checked J. O. DUSEK 1/85
Approved by
Title
Date
Sheet No.
Drawing No.
FORM SCS-355 (NOV. 1964)



APPENDIX C

SOUTH BRANCH HEART RIVER PROFILES

SOUTH HEART
FLOOD PLAIN MANAGEMENT STUDY

STARK COUNTY NORTH DAKOTA

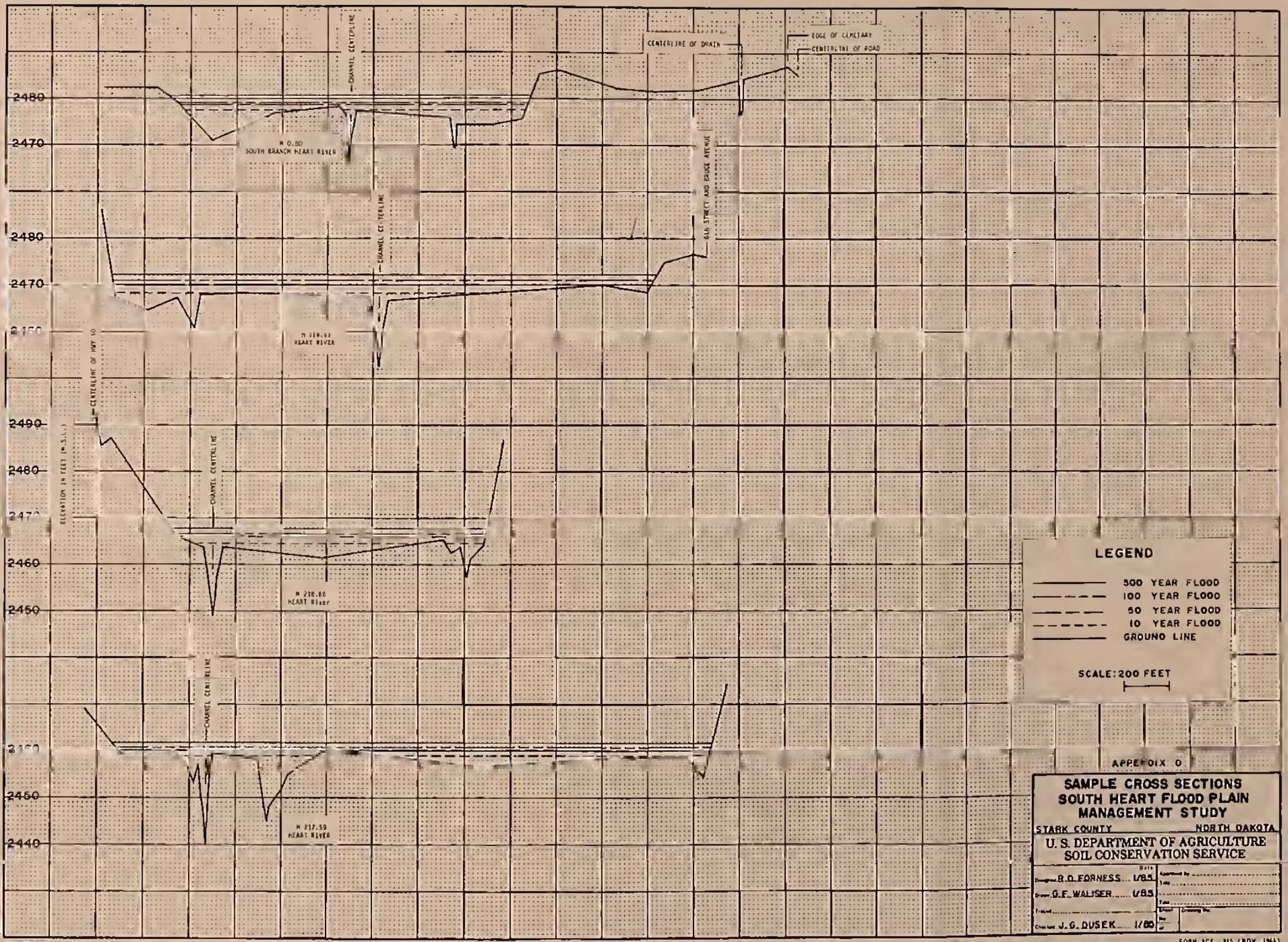
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

R.O. FORNESS 10/

O.F. WALISER 1/8

J. G. DUSEK 1/85

FORM SCS - 311 (NOV. 1966)



APPENDIX D

SAMPLE CROSS SECTIONS
SOUTH HEART FLOOD PLAIN MANAGEMENT STUDY

STARK COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	R.D. FORNESS	1/85	Approved by
Drawn	G.F. WALISER	1/85	Title
Traced			Date
Checked	J.G. DUSEK	1/85	Sheet No. / Drawing No.

DISCHARGE--FREQUENCY DATA

HEART RIVER

STARK COUNTY

APPENDIX E

HEART RIVER					
BETWEEN RIVER MILES	DRAINAGE AREA (SQUARE MILES)	500-YEAR FREQ. FLOOD Q (CFS)	100-YEAR FREQ. FLOOD Q (CFS)	50-YEAR FREQ. FLOOD Q (CFS)	10-YEAR FREQ. FLOOD Q (CFS)
216.68					
	264	18,500	11,100	9,000	4,600
220.71					
	118	12,000	7,250	5,850	3,000
221.66					

SOUTH BRANCH					
BETWEEN RIVER MILES	DRAINAGE AREA (SQUARE MILES)	500-YEAR FREQ. FLOOD Q (CFS)	100-YEAR FREQ. FLOOD Q (CFS)	50-YEAR FREQ. FLOOD Q (CFS)	10-YEAR FREQ. FLOOD Q (CFS)
0.0					
	144	13,400	8,100	6,500	3,180
1.13					

WATER SURFACE ELEVATION - FREQUENCY DATA

HEART RIVER

STARK COUNTY

APPENDIX F

HEART RIVER EXISTING CONDITION

RIVER MILE 1/	500-YEAR FREQ. FLOOD ELEVATION (M.S.L.)	100-YEAR FREQ. FLOOD ELEVATION (M.S.L.)	50-YEAR FREQ. FLOOD ELEVATION (M.S.L.)	10-YEAR FREQ. FLOOD ELEVATION (M.S.L.)
216.80	2459.0	2457.6	2457.1	2455.5
217.59	2461.7	2460.6	2460.2	2458.9
217.92	2463.8	2462.4	2462.0	2460.4
218.66	2467.8	2466.5	2465.9	2464.5
219.29	2468.8	2467.4	2466.8	2465.5
219.31	2471.1	2469.9	2469.2	2466.5
219.33	2471.1	2469.9	2469.2	2466.5
219.62	2471.7	2470.6	2470.1	2468.3
220.06	2473.1	2471.9	2471.5	2470.1
221.11	2479.5	2477.6	2476.8	2475.0
221.63	2482.5	2480.5	2479.7	2477.6

1/ River mile 0.0 is at the confluence of the Missouri River

WATER SURFACE ELEVATION - FREQUENCY DATA

SOUTH BRANCH - HEART RIVER

STARK COUNTY

APPENDIX F

SOUTH BRANCH - HEART RIVER EXISTING CONDITION

RIVER MILE 1/	500-YEAR FREQ. FLOOD ELEVATION (M.S.L.)	100-YEAR FREQ. FLOOD ELEVATION (M.S.L.)	50-YEAR FREQ. FLOOD ELEVATION (M.S.L.)	10-YEAR FREQ. FLOOD ELEVATION (M.S.L.)
0.14	2477.8	2476.0	2475.2	2473.6
0.16	2479.5	2477.2	2476.2	2474.1
0.47	2479.7	2477.4	2476.6	2474.7
0.50	2480.0	2478.1	2477.6	2476.5
0.80	2480.8	2479.2	2478.8	2477.6
1.00	2483.0	2481.8	2481.5	2480.4

1/ River mile 0.0 is at R.M. 220.71 of the Heart River

APPENDIX G

INVESTIGATION & ANALYSES

Surveys

A bench mark circuit was established throughout the study area using existing U.S.G.S. Coast and Geodetic Bench Marks. Elevation reference marks are scattered throughout the study area. These reference marks can be used to determine flood elevations as indicated in this flood hazard analyses. Detailed locations, descriptions and elevations can be obtained from Appendix J. Third order levels were used as the base of accuracy in field surveys.

A total of 17 channel and flood plain cross sections, covering a channel distance of 6.11 miles, were field surveyed and analyzed.

The geometry of all bridges and culverts were measured and used in computing the water surface profiles.

All cross sections are located on the photomaps (Appendix B, Sheets 1 to 4).

Photogrammetry

High level aerial photography flights were flown in October 1983. This photography was used for compilation of the final photo maps. The 100-year and 500-year curvilinear flood boundaries were field mapped using elevations computed from water surface profiles.

Hydrology and Hydraulics

Peak discharges for the 10-, 50-, 100-, and 500-year frequencies are based on a study of U.S.G.S. stream gage data from records of the Heart River and fourteen other stations in nearby waterhseds having similar hydrologic characteristics.

Peak discharges vary throughout the study area depending on the size and other characteristics of the contributing drainage area.

The drainage area at the beginning of the study area is approximately 264 square miles and reduces to 118 square miles at the upper end.

Water surface elevations for the 10-, 50-, 100- and 500-year flood events were computed using the U.S. Soil Conservation Service WSP-2 computer program, which performs subcritical backwater computations by a modified standard step method. The program includes head loss computations at restricted sections such as roadway bridge openings or culverts, using the contracted opening formula.

Roughness coefficients (Manning's "n") used in the hydraulic computations were chosen using U.S. Soil Conservation Service guidelines. The channel value varied from 0.045 to 0.060 while the flood plain value ranged from 0.060 to 0.090. To determine the starting elevations at mile 216.80, water surface profiles were computed using friction slope values parallel to the floodplain slope.

The hydraulic analyses for this study were based on unobstructed flow. The flow elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly and do not fail. The 100-year flood was computed to emphasize the effect of constrictions

(bridge openings) on flooding and provide a basis for analyzing future improvements. Future projections indicate that expected encroachment will affect the flood stages a slight amount within the study area. The 100-year flood also serves as the base flood which HUD considers as a minimum for flood insurance requirements.

EXISTING BRIDGES AND CULVERTS

APPENDIX H

Bridges and culverts existing at the time of study and used to develop the water surface profile data contained in this document are shown pictorially on the following pages.

The pictures should be helpful in the future to visually check which bridges were in place at the time of study, which were restrictive or in need of replacement and which have been subsequently replaced thus affecting localized flood plains.

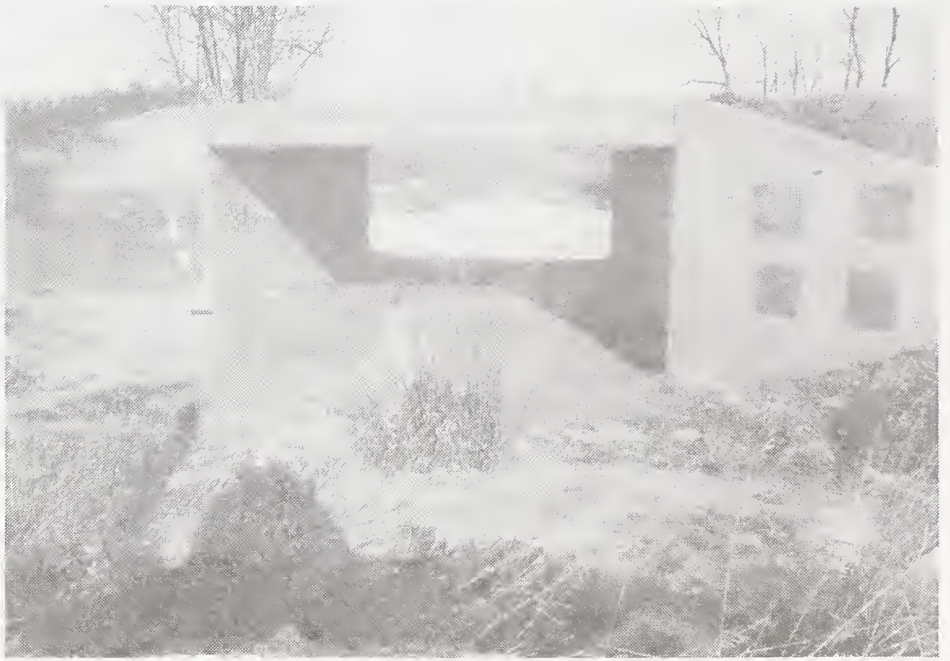
M219.31 Bridge in the flood plain on County Highway 4511

M219.31 Heart River bridge on County Highway 4511

MO.16 Railroad bridge in Section 11, T. 139 N., R. 98 W.

MO.16 Railroad bridge on the overflow channel at the west edge of South Heart

MO.50 Township bridge in Section 14, T. 139 N., R. 98 W.



MO.50 Township bridge on the overflow channel between Sections 12 and 13, T. 139 N., R. 98 W.

APPENDIX I

GLOSSARY

Acre-Foot -- The amount of water that will cover one acre to a depth of one foot. Equals 43,560 cubic feet.

Backwater -- The resulting high water surface in a given stream due to a downstream restriction or high stages in an intersecting stream.

Channel -- A natural or artificial watercourse with definite bed and banks to confine and conduct continuously or periodically flowing water.

Cubic Feet Per Second -- Rate of fluid flow at which one cubic foot of fluid passes a measuring point in one second (cfs).

Discharge -- The rate of flow or volume per unit of time. In this report discharge is expressed in cubic feet per second (cfs).

Flood -- An overflow of water onto lands not normally covered by water. The inundation is temporary and the land is adjacent to and inundated by overflow from a river, stream, ocean, lake or other body of standing water.

Flood Frequency -- An expression of how often a flood event of a given magnitude will, on the average, be equaled or exceeded. The word "frequency" often is omitted in discussing a flood event for the purpose of abbreviation.

Examples"

10-year flood or 10-year frequency flood - the flood which can be expected to be equaled or exceeded on an average of once in 10 years; and which would have a 10 percent chance of being equaled or exceeded in any given year.

50-year flood - ...two percent chance...in any given year.

100-year flood - ...one percent chance...in any given year.

500-year flood - ...two-tenths percent chance...in any given year.

Flood Peak or Peak Discharge -- The highest stage or discharge attained during a flood.

Flood Plain, Flood Prone Area or Flood Hazard Area -- Land adjoining a stream (or other body of water) which may be temporarily covered by flood water.

Flood Plain Encroachment -- Placement of fill or structures in the flood plain which may impede flood flow and cause backwater.

Flood Proofing -- A combination of structural provisions, changes or adjustments to properties and structures subject to flooding for the reduction or elimination of flood damages to properties, water and sanitary facilities, structures and contents of buildings in a flood hazard area.

Flood Routing -- Computation of the changes in streamflow as a flood moves downstream. The results provide hydrographs of discharge versus time at given points on the stream.

Flood Stage -- The stage or elevation at which overflow of the natural banks of a stream or body of water begins in the reach or area.

Hydrograph -- A plotted curve showing the rise and fall of flood discharge with respect to time at a specific point on a stream.

Natural Storage Area -- In this report, refers to depressional areas, marshes, lakes and swamps that temporarily store a portion of the surface runoff.

Riparian -- Land bordering a waterbody or watercourse.

Runoff -- In this report, refers to the portion of precipitation (including snowmelt) that flows across the land surface and contributes to stream or flood flow.

Stage Discharge Curve -- A plotted curve showing the variation of discharge with water surface elevation at a point on a stream.

Stage-Storage Curve -- A plotted curve showing the accumulated storage available for floodwater upstream from a point on a stream versus the stage at that point.

Valley Cross Section -- The relationship of the elevation of the ground to the horizontal distance across a valley perpendicular to the direction of flow.

Watershed -- A drainage basin or area which collects and transmits runoff to the outlet of the basin.

Watershed Boundary or Drainage Boundary -- The divide separating one watershed from another.

Water Surface Profile -- The relationship of water surface elevation to stream channel elevation at points along a stream, generally drawn to shown the water surface elevation for the peak of a specific flood, but may be prepared for conditions at any given time.

APPENDIX J

ELEVATION REFERENCE MARKS

SOUTH HEART FLOOD PLAIN MANAGEMENT STUDY

R.M. No.	Elevation (MSL)	R.M.'s Description
RM-2 1/	2476.60	Chiseled X in the N.W. corner wingwall of the bridge approx. 650 ft. west of the S.W. cor. Sec. 12, T. 139 N., R. 98 W., before the 1st curve of road heading west from South Heart.
RM-10 1/	2472.82	Top of furthest north bolt of the N.E. cor. of bridge approx. 650 ft. north of city limits on the first bridge going north on road to Hwy. 10 from the city of South Heart.
RM-11 1/	2472.24	Chiseled X N.E. cor. of 2nd bridge going N. on road to Hwy. 10 from the city of South Heart.
RM-13 1/	2479.54	Railroad spike in power pole S.E. cor. of intersection of road to new lagoon and R.R. tracks approx. 400 ft. N. of S.E. cor. Sec. 12, T. 139 N., R. 98 W.
RM-16 1/	2485.23	Top of N.W. cor. of hydrant at 5th St. & James Dr. in South Heart.
RM-25 1/	2475.44	Top of N.E. concrete abutment on R.R. bridge approx. 3650 ft. from centerline 4th st. and centerline main track
RM-26 3/	2480.40	High point of railroad spike in the north end of the west wood stringer on bridge over the Heart River between Sections 10 and 11, T. 139 N., R. 98 W.

1/ Reference mark established for SCS by Veigel Engineering, PC.

2/ Reference mark established by U.S.C.&G.S.

3/ Reference mark established by SCS.

APPENDIX K

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